HNF-37988
Revision 0

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Toxicological and Structural Consequences From Sodium-Water Reaction in Cell Containing the Secondary Sodium Tank

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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P.O. Box 1000
Richland, Washington

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Program/Project: FFTF

R. M. Marusich
Fluor Government Group

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TOXICOLOGICAL AND STRUCTURAL CONSEQUENCES FROM SODIUM-WATER REACTION IN CELL CONTAINING THE SECONDARY SODIUM TANK

R. M. Marusich
Fluor Government Group
June 2008

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Toxicological and Structural Consequences from Sodium-Water Reaction in Cell Containing the Secondary Sodium Tank

1.0 INTRODUCTION

1.1 PURPOSE

The analysis will show the consequences should the solid sodium in the Secondary Sodium Tank react with a presumed layer of water in the cell. The Peer Review Checklist is attached.

1.2 PHYSICAL DATA

Tank T-44 is the Secondary Sodium Tank. The tank is 12 ft in diameter. The body of the tank is 31 ft, 8 inches long (31.67 ft). There is an ellipsoidal head on both ends. The total length with the heads is 38 ft, 7.625 in. The head and shell thicknesses are 1.125 inches each. (Data from Drawing H-4-11713).

Tank T-44 is in a cell. The base of the cell is at El. 503 ft, 0 inches. The cell is 24 ft tall, 43 ft long and 20 ft wide (data per drawing H-4-14416). (See Figure 1) The only openings are in the top of the cell.

1.3 ASSUMPTIONS

1. 30 gallons of sodium are in Tank T-44 (email from Tom Burke to R. Marusich – Attachment 1). The sodium is solid. It is assumed to be evenly distributed over the bottom of Tank T-44.

2. Sodium fills the base of the tank from one end of the barrel to the other. To simplify, the determination of sodium thickness, it is assumed that there is no sodium in the ellipsoidal heads.

3. Pool of water exists on the floor of the cell containing Tank T-44. The depth of the pool is slightly greater than the peak thickness of the solid sodium volume in the tank.

4. Tank T-44 immediately and catastrophically fails such that all of the sodium in the tank enters the water at the same time.

5. Since the sodium density is less than that for water, sodium floats in water. Therefore, the top surface of the solid chunk of sodium does not react with water.

6. The reaction rate, as a function of the area (units of g/s-cm^2) of solid sodium in the water, for a large chunk of solid sodium is the same as that taken from small samples.

7. All hydrogen from the sodium-water reaction immediately reacts with air on the surface of the sodium due to the heat of the reaction (i.e., hydrogen auto-ignites and "burns" in air).

8. Expansion of the cell air due to the heat of the sodium-water reaction transports the suspended sodium hydroxide out of the cell.

9. The distance to the offsite person is 4.5 miles per FFTF Safety Analysis Report.

2.0 REACTION OF SODIUM AND WATER

Per e-mail from Tom Burke to R. Marusich (Attachment 1), 30 gallons of sodium are in the tank. It is assumed that the tank "disappears" instantly (a long crack opens in the base of the tank) and 30 gallons of solid sodium enters a presumed pool of water on the floor of the cell such that all of the sodium reacts.

2.1 REACTION EQUATION

The reaction is

$$Na + H_2O \rightarrow NaOH + 0.5\ H_2. \qquad (1)$$

Hydrogen tends to burn immediately in the pressure of air. The sodium hydroxide dissolves in the water.

It is assumed that all of the hydrogen immediately reacts with air as it is generated. Therefore the reaction is

$$Na + H_2O \rightarrow NaOH + 0.5\ H_2$$
$$0.5\ H_2 + 0.25\ O_2 \rightarrow 0.5\ H_2O$$

or

$$Na + 0.5\ H_2O + 0.25\ O_2 \rightarrow NaOH. \qquad (2)$$

2.2 REACTION HEAT AND RESULTS OF AN INSTANTEOUS REACTION

The heat of reaction is found by subtracting the heat of formation of the reactants from that of the products.

The heats of formation are:

H_2	0
Na	0

O_2	0
H_2O (liquid)	-68.3 kcal/mole
NaOH	-101.96 if NaOH remains a solid
	-112.2 if NaOH goes into solution at 1 part per 400 parts water.

Assume NaOH goes into solution as this is most likely the case and, also, is a worst case condition. Then the heat of reaction using, Equation 2, is:

$$
\begin{aligned}
H_{reaction} &= -112.2 - [(-68.3)(0.5) + 1(0) + 0.25(0)] \\
&= 78 \text{ kcal/mole Na} \\
&= 327 \text{ kJ/mole Na}
\end{aligned}
$$

There are 30 gallons of sodium or 0.114 m^3. The density of solid sodium is 968 kg/m^3. There is 110 kg or 4783 moles (using 23 g/mole).

The heat liberated by the reaction is

$$
\begin{aligned}
H &= (327 \text{ kJ/mole})(4783 \text{ moles}) \\
&= 1.56 \times 10^6 \text{ kJ or } 1.56 \times 10^9 \text{ J.}
\end{aligned}
$$

The volume of the cell is determined next. Since the sodium tank has an opening that runs the full length of the tank and is 2 ft wide (see Section 2.1), the void volume within the tank is counted in the volume of the cell. The volume of water on the floor is negligible as compared to the over-all cell volume. The tank volume is

$$
\begin{aligned}
V &= (24 \text{ ft})(20 \text{ ft})(43 \text{ ft}) \\
&= 20{,}640 \text{ ft}^3 \\
&= 5.84 \times 10^5 \text{ L.}
\end{aligned}
$$

At 298 K and 1 atm (initial conditions), there is 23,900 moles of air (using the ideal gas law with the gas constant of 0.082 L-atm/mole-K) in 5.84×10^5 L.

Air is mainly composed of 79% nitrogen and 21% oxygen. Therefore, of the 23,900 moles of air in the cell, there are 18,880 moles of nitrogen and 5020 moles of oxygen. After the reaction there are fewer moles of oxygen. One mole of sodium reacts with 0.25 moles of oxygen. There are 4783 moles of sodium. So, after the reaction there are 1196 fewer moles of oxygen. At the completion of the reaction, the total moles in the atmosphere in the cell are 18,880 moles of nitrogen and 3820 moles of oxygen for a total of 22,700 moles. Cell pressurization is due to expansion of the air due to heating.

The average specific heat of nitrogen and oxygen between 300 K and 3000 K is 1.18 J/g-K and 1.08 J/g-K, respectively (Data from www.engineeringtoolbox.com). Ignore the water vapor that may go into the air by the heat of the reaction and assume all heat goes to the air. The temperature increase is found by the equation below. The heat absorbed by the water and that absorbed by the walls is ignored for conservatism and due to the speed of the reaction (see Section 2.1). The equation is:

$$Q = mC_v\Delta T$$

Where Q = heat added, kJ
= 1.56×10^9 J
m = mass in atmosphere, moles
= 18,880 moles of nitrogen
= 3820 moles of oxygen
R = ideal gas law constant
= 8.314 J/mole-K
C_p = specific heat of nitrogen at constant pressure
= (1.18 kJ/kg-k)(28 g/mole)
= 33 J/mole-K
C_v = specific heat of nitrogen at constant volume, J/mole-K
= $C_p - R$
= 24.7 J/mole-K
C_p = specific heat of oxygen at constant pressure
= (1.08 kJ/kg-k)(32 g/mole)
= 34.6 J/mole-K
C_v = specific heat of oxygen at constant volume, J/mole-K
= $C_p - R$
= 26.3 J/mole-K
ΔT = temperature rise, K.

Using the end point moles of nitrogen and oxygen (18,880 moles of nitrogen and 3820 moles of oxygen) and solving, yields a value for ΔT of 2750 K. The final temperature is 3050 K.

The final pressure, using the ideal gas law with 3050 K, 18,880 moles of nitrogen and 3820 moles of oxygen is 9.7 atm or 143 psia or 128 psig.

3.0 TIME VARYING REACTION

3.1 REACTION RATE

The sodium-water reaction is not instantaneous, however. Page 12 of *Modeling and Control Scoping Study* for the ANL-WEST Sodium Facility Reaction Vessel states that a 1 cm^3 cube (weighs about 1 gram) of sodium took 10 seconds to fully dissolve in a beaker of water at room temperature.

The density of sodium is 968 kg/m^3 or 0.968 g/cm^3. A 1 cm^3 piece weighs 0.968 g. The area of one of the sides is 1 cm^2. Assuming the cube floats such that 5 of the 6 sides contact water, the reaction rate is

$$\frac{0.968\,g}{10\,s}\left(\frac{1}{5\,cm^2}\right) = 0.019\,g/s - cm^2 \ \textit{which is rounded up to}\ 0.02\,g/cm^2 - s$$

Sodium fills the bottom of the tank. There are 30 gallons of sodium or 0.114 m^3. The tank is 31.67 ft long with ellipsoidal heads. It is assumed that there is no sodium in the ellipsoidal heads to determine the height of solid sodium in the tank, the area of a circular segment must be determined.

The area of a circular segment (see Figure 2) is taken from standard handbook geometrical equations for areas of portions of a circle. The area is:

$$A = \frac{r^2}{2}(\theta - \sin\theta)$$

Where, in this case r = 6 ft or 72 in.

The volume of sodium is 0.114 m^3 or 4 ft^3. The length of the solid sodium is 31.67 ft (or 9.7 m). The area is 0.126 ft^2 or 18.2 in^2.

Solving for θ yields 0.349 radians.

The value of (r-h) is

$$\cos\left(\frac{\theta}{2}\right) = \frac{(r-h)}{r}$$

Solving for (r-h) yields 70.91 in. This makes "h" 1.09 inches (as r is 72 inches).

The flat surface of the circular segment is

$$2r\left(\sin\frac{\theta}{2}\right) = 25\,inches$$

The arc length given by:

$$Arc\,length = \frac{\pi(12\ ft)(0.349\,radians)}{(2\pi\,radians)} = 2.09\,ft$$

$$=25\ in.$$

The section entitled *Mensuration Formulas* of the *Chemical Engineers Handbook* provides two equations for the area of a circular segment. They are

$$A = \frac{r^2}{2}(\theta - \sin\theta)$$

and

$$A\left[r^2 \cos^{-1}\left(\frac{r-H}{r}\right)\right] - (r-H)\left[(2rH - H^2)^{0.5}\right]$$

where the terms are as described above using the second equation with A = 18.2 in^2 and r = 72 in., the value of H is found to be 1.09 in.

Using H = 1.09 in. and r = 72 in., (r-h) is 70.9 in. From Figure 1

$$\frac{\ell}{2} = \left[r^2 - (r-h)^2\right]^{0.5} = 12.48\ in.$$

The length (2 * ℓ/2) is 25 in.

The angle θ is found to be

$$a\cos\frac{\theta}{2} = \frac{r-h}{r}$$

$$\theta = 20^\circ\ or\ 0.349\ radius$$

Assume the entire piece enters the water at the same time. Sodium is less dense than is water therefore it floats on the surface but almost submerged. As a result, only the bottom portion will assumed to react. The reaction area is the arc length times length

Reaction area = [(25 in.)(2.54 cm/in)][(9.7 m)(100 cm/m)]
= 6.16 x 10^4 cm^2

It is assumed that the reaction rate found above for small pieces of solid sodium can be applied to large pieces as well. The reaction rate is

$$\text{Re}action\ Rate = \left(\frac{0.02\ g}{s-cm^2}\right)\left(6.16\ x\ 10^4\ cm^2\right)$$
$$= 1232\ g, Na/s.$$

Since there are 110 kg of sodium, the duration of the reaction is:

$$duration = \frac{(110\ kg)(1000\ g/kg)}{1232\ g/s}$$
$$= 90\ s\ (rounded\ up).$$

3.2 TOXICOLOGICAL CONSEQUENCES

There are 4 different openings in the ceiling of the cell (see Attachment 2). The ventilation duct penetrates the ceiling in the SW corner of the cell. A pipe chase penetrates the ceiling in the SE corner. Electrical conduit penetrate the ceiling near the center of the cell. An opening exists in the ceiling toward the north end to allow manned entry into the cell. There is a hatch cover over this opening. The pipe chase and electrical conduit are sealed, in that one can not look into the cell, however these seals are not air tight and could be blown out.

For purposes of this analysis it is assumed that all of the generated NaOH is suspended in the atmosphere of the cell and is transported out of the cell due to expansion of the cell atmosphere caused by the heat generated by the reaction.

The generation rate of sodium hydroxide is found from the chemical reaction in which 1 mole of sodium reacted to form 1 mole of sodium hydroxide.

The generation rate of sodium hydroxide is

$$NaOH\ rate = \left(\frac{1232\ g, Na/s}{23\ g,\ Na/mole}\right)\left(\frac{1\ mole\ NaOH}{1\ mole\ Na}\right)$$
$$= 53.6\ moles,\ NaOH/s\ \ or\ \ 2143\ g,\ NaOH/s.$$

The sodium hydroxide release from the cell is due to heating of the air causing buoyancy and expansion (like a fire). The energy release rate comes from the reaction rate. Using the reaction where hydrogen burns as it is created.

H = 327 kJ/mole

Then

$$\frac{dQ}{dt} = \left(\frac{327\ kJ}{mole}\right)\left(\frac{1232\ g, Na}{s}\right)\left(\frac{mole}{23\ g}\right)$$
$$= 1.75\ x\ 10^7\ J/s$$
$$= 18\ Mw\ (rounded\ up)$$

There are two cases to be considered for toxicological release. The first is the unmitigated case. In this case the heat from the reaction causes the air in the cell to expand. The expanding air carries the NaOH particles out of the cell into the atmosphere where wind carries it downwind. The other case is where the building above the cell exists. The expanding air carries sodium into the building. It can still be transported out of the facility but not as an expanding plume. In this case the release is an area source as the release will travel through a number of external exits to the building, to the atmosphere and then carried downwind as a non-buoyant plume.

The first case considered will be the unmitigated case. The downwind concentration of sodium hydroxide is given by

$$C = (G)(X/Q)$$

Where G = release rate of sodium hydroxide, mg/s
= 2.2×10^6 mg/s (2200 g/s)
X/Q = measure of atmosphere dispersion, s/m^3 (see below)
C = concentration, mg/m^3

The X/Q is obtained from a RADIDOSE spreadsheet (see Attachment 3). RADIDOSE is a DOE-approved method for determining consequences (HNF-26181). Numerical values are needed for the following input cells to obtain X/Q:

- heat release flag = 4 (Cell H19),
- heat release (Mw), (Cell H20),
- diameter of heat release area, m, (Cell H21),
- distance to offsite person = (Cell H18),
- distance to onsite person = (Cell 16)
- Hanford Area of interest = 4 (Cell H15), and
- All other cells remain at their default value.

In this case
Cell H16 = 100 m, a typical safety analysis value,
Cell H18 = 7243 m based on a distance of 4.5 miles per the FFTF Safety Analysis Report,
Cell H20 = 18 (units are Mw),
Cell H21 = 10 m (see below).

The diameter is taken to be the diameter of a circle whose area equals that of the cell as the larger the diameter, the greater the X/Q. The cell is 43 ft by 20 ft. The equivalent diameter is 33 ft or 10 m. So the input to Cell H21 is 10 meters.

The X/Q is found to be (See Attachment 3).

- 6.9×10^{-5} onsite (Cell G39), and
- 2.6×10^{-6} offsite (Cell I39).

Using these values, the sodium hydroxide concentration is

- 152 mg/m^3 onsite, and
- 6 mg/m^3 offsite.

The limits for toxicological releases are given in terms of ERPG. For sodium hydroxide

ERPG-1 = 0.5 mg/m^3
ERPG-2 = 5 mg/m^3
ERPG-3 = 50 mg/m^3

The onsite concentration exceeds ERPG-3. The offsite concentration is ERPG-2.

Consider a case where there is some heat transfer to the walls, ceiling and equipment. This assumption is made to see how cooling affects the toxicological release. A lower heat rate results in a lower plume height and greater concentration of sodium hydroxide. For purposes of illustration, assume the cooling is such that the effective heat rate is 4 Mw not 18 Mw. This corresponds to the walls, ceiling and equipment absorbing 75% of the generated heat. Now χ/Q is (See Attachment 2)

- 2.8×10^{-4} onsite, and
- 8.7×10^{-6} offsite.

The concentration is

616 mg/m^3 onsite (exceeds ERPG-3), and
19 mg/m^3 offsite (exceeds ERPG-2).

Even at a lesser heat rate, the effect (in terms of which ERPG is exceeded) remains the same.

Thus for the case of a unmitigated release,

- the onsite concentration (at 100 m) exceeds ERPG-3, and
- the offsite concentration exceeds ERPG-2 but not ERPG-3.

The concentrations from both of these calculations are "HIGH Consequences" per Table 2-3 of HNF-8739, *Hanford Safety Analysis and Risk Assessment Handbook (SARAH)*, Rev. 1. As a result there is no need to look at the case of a release into the building. Those results cannot be any worse (in terms of categorization).

3.3 PRESSURIZATION

Section 1.4 shows that the cell pressurization is due to expansion of the air due to heating. The final air temperature, shown in Section 1.4 is 3050 K. At 1 atm, and 22,700 moles (endpoint conditions after some oxygen is used in the reaction with sodium), the volume needed to accommodate these conditions is

$$V = \frac{nRT}{P}$$

$$= \frac{(22{,}700\ moles)(0.082\ L-atm/mole-K)(3050\ K)}{1\ atm}$$

$$= 5.68\ x\ 10^6\ L$$

The initial volume is 5.84 x 10^5 L.

Section 2.1 shows that the reaction is over in 90 seconds. The average air flow rate that has to be accommodated to prevent any pressurization is

$$\frac{5.68\ x\ 10^6\ L - 5.84\ x\ 10^5\ L}{90\,s} = 56{,}600\ L/s \text{ or } 2000 \text{ ft}^3\text{/s}$$

The hatch in the NW part of the cell is 8 ft by 4 ft (scaling off drawing H-4-13119). The area is 32 ft^2.

Now to find the pressure drop that corresponds to a flow rate of 56,600 L/s out of a 32 ft^2 opening. The Crane Technical Paper 410, *Flow of Fluids through Valves, Fittings and Pipe* gives equations for compressible flow.

$$q = 6.87 \frac{Y\ d_0^2\ C}{S_g} (\Delta P \rho_u)^{0.5}$$

Where Y = expansion factor
= 1 for small values of ΔP per pg. A-21 of the reference
d_0 = diameter of opening, in.
= 64 in. [from hydraulic diameter = 4 (Area)/(perimeter)]
C = flow coefficient
= 1.0 for a nozzle having a small $d_{nozzle}/d_{downstream\ volume}$ ratio (see top figure on pg. A-20 of the reference)
S_g = specific gravity of gas relative to air
= 1.0
ρ_u = upstream density of air, lb/ft^3
= 0.04 lb/ft^3 (See below)
q = flow rate, ft^3/s
= 2000 ft^3/s (from 56,600 L/s)
ΔP = pressure drop, psi

The density of air at the start of the event is

$$density\ at\ start = \frac{(18{,}800\ moles\ N_2 * 28g/mole) + (5020\ moles\ O_2 * 32g/mole)}{5.84x10^5\,L} = 1.18g/L$$

At the end of the reaction, the density of the atmosphere is

$$density\ at\ end = \frac{(18{,}800\ moles\ N_2 * 28g/mole) + (3820\ moles\ O_2 * 32g/mole)}{5.55x10^6 L} = 0.117g/L$$

An average upstream value of 0.65 g/L or 0.04 lb/ft^3 will be used in the analysis.

Solving for ΔP yields 0.13 psig.

The pressure difference between the cell holding Tank T-44 and the area into which the air flows is small. This means that the area into which the air flows is also pressurizing. This area is the cell above the cell containing Tank T-44.

Now consider the conditions in the cell holding Tank T-44 and in the cell above. The cell above is 22 ft wide, 56 ft long (to the wall south of Y-9 and Y-12) and 17.75 ft tall (assuming that the ceiling is 2 ft thick (scaled off of the drawing). The volume is 6.2 x 10^5 L. The volume is about the same as the cell holding Tank T-44.

The number of moles in the cell above is 25,400 at 1 atm and 298 K. Assume no cooling and complete mixing such that the temperature rise in both rooms is half that in the cell holding Tank T-44 or one-half of 2750 K or 1375 K. The final temperature in both cells is 1673 K. The total moles in both rooms is

Total moles = 18,880 + 3820 + 25,400 = 48,100 moles.

Using the ideal gas law with 48,100 moles, 1673 K and 1.2 x 10^6 L, yields a final pressure of 5.5 atm or 66 psig.

The effects of the pressure increase are as follows:

- The ventilation duct will likely be blown out at some location. If the duct can withstand the forces due to the flow resulting from a pressure of 65 psig, the filters will be blown out.
- The North wall (wall between equipment E-604 and Y-9 and Y-12) does not appear to be a substantial wall and as a result will likely fail.
- The hatch cover and the packing in the electrical and piping penetration between the cell holding Tank T-44 and the cell above will blow out. Drawing H-4-13123 shows what appears to be a concrete block wall in the East wall of the cell above that which holds Tank T-44. If this is the case, the block will be blown out.
- The cell adjoining the one above that holding Tank T-44 will be pressurized and experience similar structural failures as those listed above, if the wall is concrete block. This effect could cascade into other cells depending on the details of construction, the large flow paths to other cells (e.g., stairways) and speed of cooling.

4.0 REFERENCES

H-4-11713, 1977, *Design Layout Drawing for Vessel T-44*, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

H-4-13123, 1975, *Equipment Location HTS Service BLDG West Sect GC-GC*, Rev. 6, Westinghouse Hanford Company, Richland, Washington.

H-4-14416, 1974, *HTS Service Building West Substr. Tank T-44 Cell Conc. Outline and Reinf.*, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

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HNF-8739, 2004, *Hanford Safety Analysis and Risk Assessment Handbook (SARAH)*, Rev. 1, Fluor Hanford, Inc., Richland, Washington.

HNF-26181, 2005, *Users Guide and Model Description for RADIDOSE Version 3.0*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

Perry, R. H., C. H. Chilton, and S. D. Kirkpatrick, 1997, *Perry's Chemical Engineers' Handbook*, 7th edition, McGraw-Hill Book Company, Inc., New York, New York.

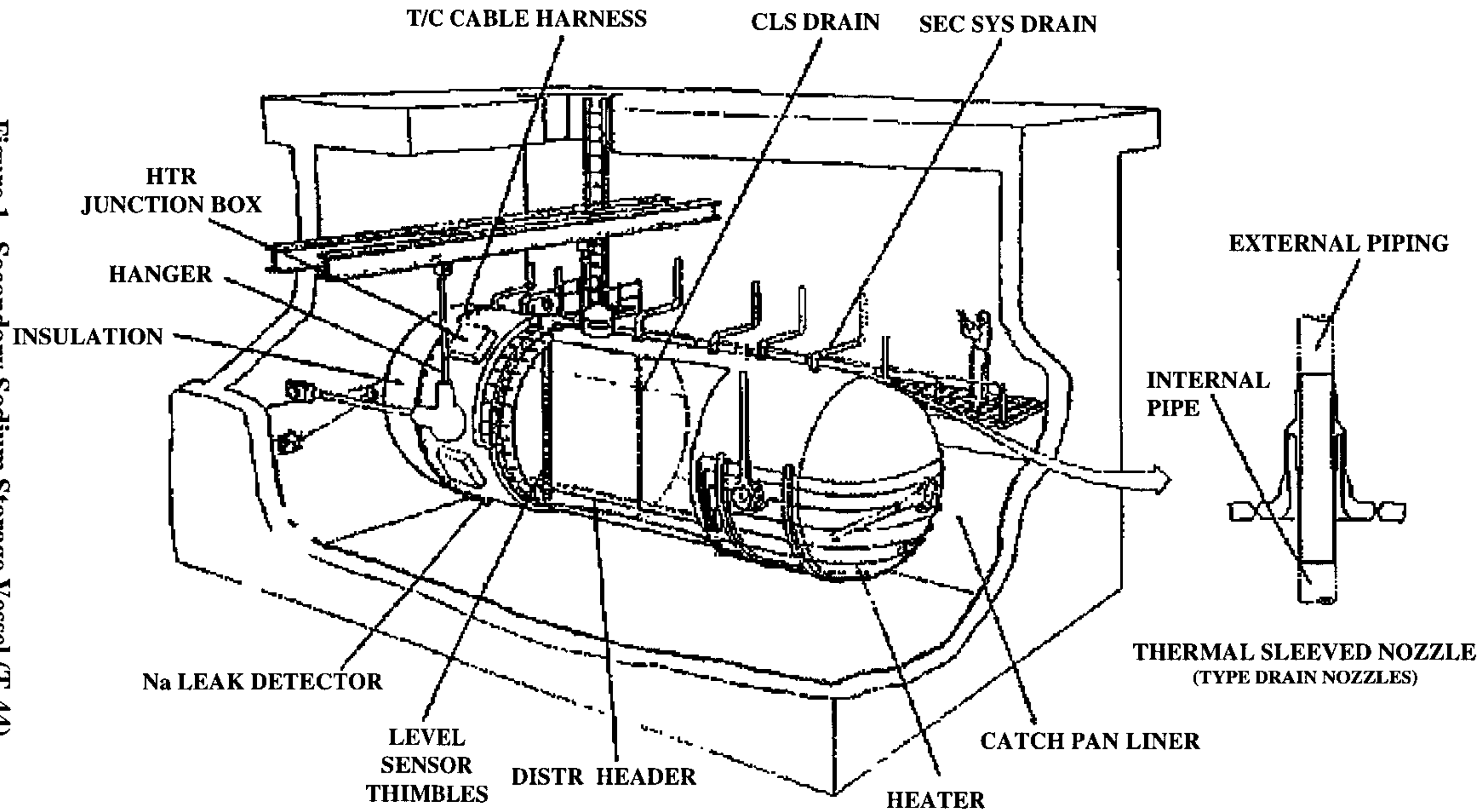

Figure 1. Secondary Sodium Storage Vessel (T-44)

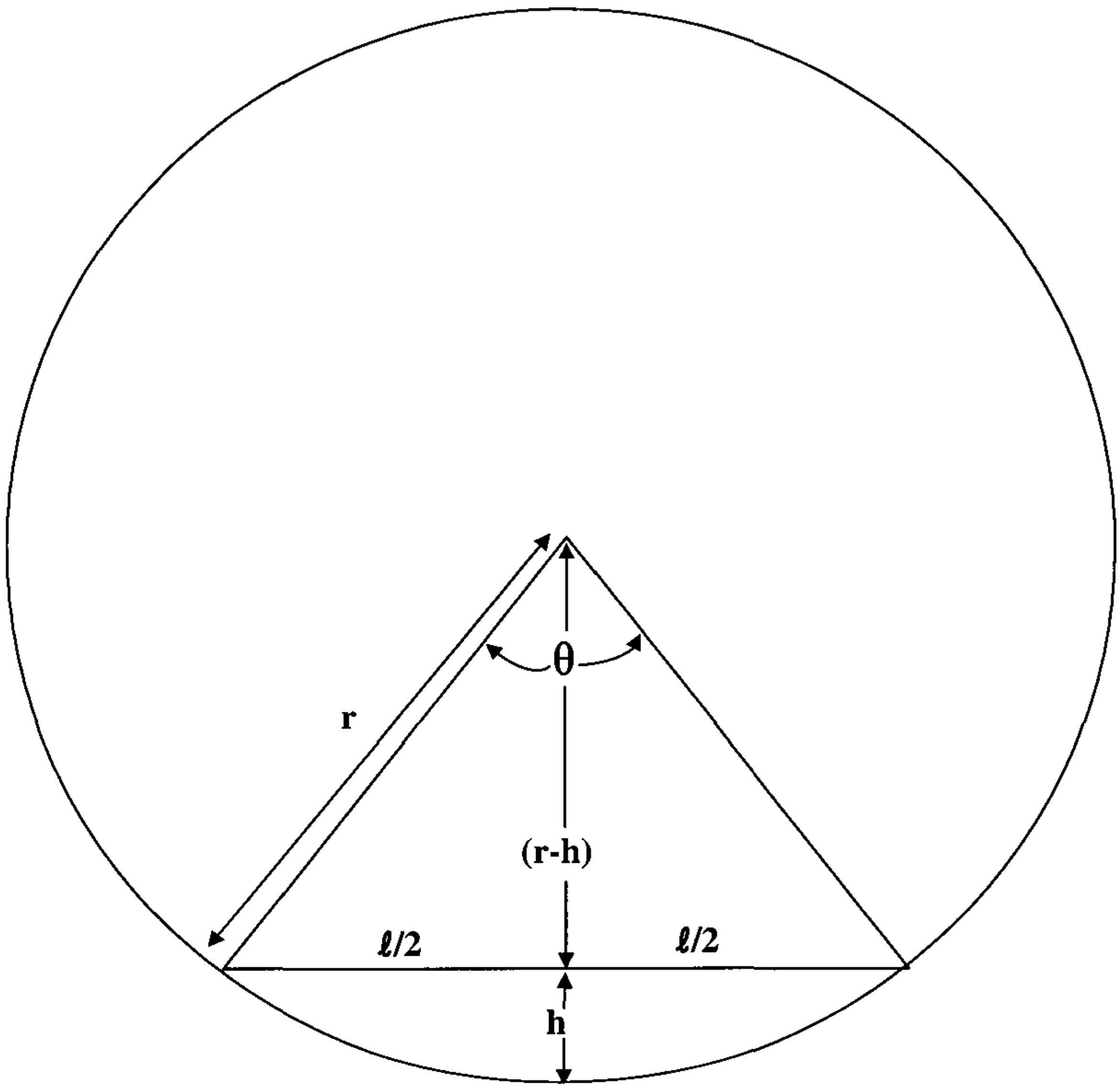

Figure 2. Area of A Circular Segment

ATTACHMENT 1 – EMAIL FROM TM BURKE TO RM MARUSICH

From: Burke, Thomas M (Tom)
Sent: Friday, February 29, 2008 3:43 PM
To: Marusich, Robert M
Subject: Analysis of Sodium-Water Reaction and Hydrogen "Burn"

Bob,

I participated in a Hazard Analysis Table Top this afternoon in support of FFTF preparing to go into a long term S&M condition. Other participants were Bill Dautel, John Dale, Dave Polzin, Ed Dodd, Bernie Nowack, and Jeff Marusich. One of the "events" we decided to have analyzed is a sodium water-reaction in the cell containing our secondary sodium storage tank which has an estimated 30 gallons of residual sodium remaining in it. It was suggested that you would be the best person to do the analysis. Here is the scenario:

- A large quantity of water accumulates in the cell containing the tank
- The tank essentially "disappears" by some unspecified mechanism (corrosion over a long period of time?)
- The 30 gallons of sodium react completely with the water (Na + H2O => NaOH + 1/2H2 + Heat)
- All of the hydrogen generated is retained in the cell and mixes with the air in the cell (free volume of 13,100 ft3 per HEDL-TME 75-122). I assume the mixture will be above the LFL.
- It ignites. All of the energy from the hydrogen burn as well as the original sodium-water reaction raise the pressure in the cell (assume no leakage even though there certainly will be). What is the pressure? Is it really a detonation and treated differently than just raising the pressure?

I tried to quickly find the "design" or allowable pressure for the cell but couldn't. Maybe Bill or Dave can do that next week. I guess they'll also have to provide you with a charge code.

If you have any questions, contact me, Bill or Dave.

Thanks,

Tom Burke

Project Manager

FFTF Sodium Disposition
376-2207 (400 Area)

438-3212 (Cell)

ATTACHMENT 2 – MEMO FROM POLZIN TO MARUSICH

From: Polzin, David L (Dave)
Sent: Thursday, March 27, 2008 4:23 PM
To: Marusich, Robert M
Cc: Dautel, William A; Burke, Thomas M (Tom)
Subject: RE: Additional Data needs - Analysis of Sodium-Water Reaction and Hydrogen "Burn"

Bob,

There are 4 different openings in the floor of cell 431 that connect to cell 401 below. The H&V ducts go through an opening in the southwest corner, some piping goes through an opening in the southeast corner, some electrical conduit goes through an opening along the east wall (near the center of the room), and there is an opening toward the north end along the east wall for manned entry into cell 401. Most of these openings are closed off to some extent with grating, diamond plate, or piping/ducting/conduit passing through. If the hatch cover is open above the entry ladder into cell 401, you can look down and see the tank, piping, etc. I would also note that cell 401 communicates with a couple of pipe ways through openings in the walls. These are shown on drawing H-4-13123 and H-4-13689. Cell 401 is definitely not an air-tight cell.

Dave

Marusich, Robert M

To: Marusich, Robert M
Subject: RE: OUO Determination for Toxicological and Structural - Hydrogen From The Secondary Sodium Tank

Message forwarded from W. Dautel, FFTF concerning the OUO status of the paper.

-----Original Message-----
From: Witherspoon, Wiley V III
Sent: Tuesday, June 10, 2008 3:05 PM
To: Niebel, Sheryl A (Sheri)
Subject: RE: Coveer sheet - Toxicological and Structural - Hydrogen From The Secondary.doc

I think it is a stretch to get to OUO # 2. The closest I can get is "Can the information be used to gain access to key component of the facility to disrupt operations or harm employees?" This does not tell how to gain access, but it does give parameters used in the equation that could be used to disrupt or harm if someone could interpret and then invoke. I say no to OUO at this time. Wiley

Wiley Witherspoon PMP, CM
Program Office Manager
FFTF Fuel Offload and Asset Management
509-376-1805
509-376-4920 fax
wiley_v_iii_witherspoon@rl.gov

-----Original Message-----
From: Dautel, William A
Sent: Monday, June 09, 2008 4:12 PM
To: Burke, Thomas M (Tom); Niebel, Sheryl A (Sheri)
Subject: FW: Coveer sheet - Toxicological and Structural - Hydrogen From The Secondary.doc

Tom & Sheri,

It looks okay to me. I know of no reason that this would have to be OUO.

Bill Dautel
373-9563

-----Original Message-----
From: Marusich, Robert M
Sent: Monday, June 09, 2008 3:58 PM
To: Dautel, William A
Subject: Coveer sheet - Toxicological and Structural - Hydrogen From The Secondary.doc

Bill,

ATTACHMENT 3 - X/Q FOR THE TOXICOLOGICAL RELEASE

X/Q for the toxicological release for the FFTF sodium-water and hydrogen-air reaction which creates sodium hydroxide.

Case 1:
Q = 18 Mw
Effective pool diameter = 10 m

	E	F	G	H	I	J	K	L
1			RADIDOSE Version 3.0 (5-18-2005)					
2			**Input Parameter**	**User Input**	**Default**	**Description (based on user input)**		
3			Facility/Material (1-14):		1	Plutonium Finishing Plant: < 10% Pu-240		
4			Form of Material (1-10):		7	Pu Oxide and Other Powders		
5			Accident Type (1-6):		1	Fire		
6			Quantity at Risk (MAR):		1	gram		
7			Damage Ratio:		1			
8			Airborne Release Fraction:		6.00E-03	ARF from SARAH Table 3-4 (ARF page)		
9			Respirable Fraction:		0.1	RF from SARAH Table 3-4 (ARF page)		
10			Leak Path Factor:		1	LPF (applies to particulate only)		
11			HEPA Filter Factor:		1	DF = 1 (applies to particulate only)		
12			Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD		
13			Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult		
14			Material Solubility Class:		3	compounds are generally insoluble		
15			Hanford Processing Area (1-4):	4		400 Area		
16			Distance or X/Q for Collocated Worker:		100	meters		
17			Distance or X/Q for Onsite Public:		4,210	meters		
18			Distance or X/Q for Offsite Public:	7240		meters		
19			Emission Source Type (1-4):	4		Ground level fire		
20			Thermal Power (2 to 1000 MW):	18		MW (at 0.23 W/m^2)		
21			Pool Fire Diameter (1 to 20 m):	10		meters (Area = 78.5 m^2)		
22								
23		**Description of Accident Scenario:**				Edit using function key F2. Carriage returns are not allowed.		
24								
25								
26								
27	Offiste X/Q based on distance from FFTF to the Site Boundary which is 4.5 miles.							
28								
29								
30		**Dose Results for the Postulated Accident:**						
31		**Plutonium Finishing Plant: < 10% Pu-240 -- New composition (2004)**					**Material source amounts are**	
32				**Pu Oxide and Other Powders**			**listed on the "UnitDF" page.**	
33		**Ground Level Fire -- 18 MW -- 10.0 m Diameter**				**400 Area**		
34		Total Respirable Release:		6.00E-04	gram			
35		Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release		
36			**Collocated**	**Onsite**	**Offsite**	Duration		
37		Receptor:	**Worker**	**Public**	**Public**	1 h		
38		Distance:	100 m	4,210 m	7,240 m			
39		X/Q:	6.88E-05	2.74E-06	2.59E-06	s/m3		

Case 2:
Q = 4 Mw
Effective pool diameter = 10 m

	E-G	H	I	J-L
1	**RADIDOSE Version 3.0 (5-18-2005)**			
2	**Input Parameter**	**User Input**	**Default**	**Description (based on user input)**
3	Facility/Material (1-14):		1	Plutonium Finishing Plant: < 10% Pu-240
4	Form of Material (1-10):		7	Pu Oxide and Other Powders
5	Accident Type (1-6):		1	Fire
6	Quantity at Risk (MAR):		1	gram
7	Damage Ratio:		1	
8	Airborne Release Fraction:		6.00E-03	ARF from SARAH Table 3-4 (ARF page)
9	Respirable Fraction:		0.1	RF from SARAH Table 3-4 (ARF page)
10	Leak Path Factor:		1	LPF (applies to particulate only)
11	HEPA Filter Factor:		1	DF = 1 (applies to particulate only)
12	Collocated Worker Dose Factor:		3	ICRP 68, 5 μm AMAD
13	Onsite & Offsite Public Dose Factor:		7	ICRP 72 for Adult
14	Material Solubility Class:		3	compounds are generally insoluble
15	Hanford Processing Area (1-4):	4		400 Area
16	Distance or X/Q for Collocated Worker:		100	meters
17	Distance or X/Q for Onsite Public:		4,210	meters
18	Distance or X/Q for Offsite Public:	7240		meters
19	Emission Source Type (1-4):	4		Ground level fire
20	Thermal Power (2 to 1000 MW):	4		MW (at 0.05 W/m²)
21	Pool Fire Diameter (1 to 20 m):	10		meters (Area = 78.5 m²)
22				

	E	F	G	H	I	J	K	L
23		**Description of Accident Scenario:**			Edit using function key F2. Carriage returns are not allowed.			
24-29	Offiste X/Q based on distance from FFTF to the Site Boundary which is 4.5 miles.							
30		**Dose Results for the Postulated Accident:**						
31		**Plutonium Finishing Plant: < 10% Pu-240 -- New composition (2004)**					**Material source amounts are**	
32		**Pu Oxide and Other Powders**					**listed on the "UnitDF" page.**	
33		**Ground Level Fire -- 4 MW -- 10.0 m Diameter**				**400 Area**		
34		Total Respirable Release:		6.00E-04	gram			
35		Dose Factors:	ICRP 68, 5μm	ICRP 72 for Adult		Release		
36			**Collocated**	**Onsite**	**Offsite**	Duration		
37		Receptor:	**Worker**	**Public**	**Public**	1 h		
38		Distance:	100 m	4,210 m	7,240 m			
39		X/Q:	2.80E-04	1.22E-05	8.67E-06	s/m3		

REVIEW CHECKLIST

Document Reviewed: Toxicological and Structural Consequences from Sodium-Water Reaction in Cell Containing the Secondary Sodium Tank

Scope of Review: Analysis, methodology & calculations were checked for logic & accuracy.

Yes	No	NA		
O	O	⊗	*	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
⊗	O	O		Problem completely defined.
⊗	O	O		Accident scenarios developed in a clear and logical manner.
⊗	O	O		Necessary assumptions explicitly stated and supported.
⊗	O	O		Computer codes and data files documented.
⊗	O	O		Data used in calculations explicitly stated in document.
⊗	O	O		Data checked for consistency with original source information as applicable.
⊗	O	O		Mathematical derivation checked including dimensional consistency of results.
O	O	⊗		Models appropriate and used within range of validity or use outside range of established validity justified.
⊗	O	O		Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
O	O	⊗		Software input correct and consistent with document reviewed.
O	O	⊗		Software output consistent with input and with results reported in document reviewed.
⊗	O	O		Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
O	O	⊗		Safety margins consistent with good engineering practices.
⊗	O	O		Conclusions consistent with analytical results and applicable limits.
⊗	O	O		Results and conclusions address all points required in the problem statement.
O	O	⊗		Format consistent with appropriate NRC Regulatory Guide or other standards.
O	O	⊗	*	Review calculations, comments, and/or notes are attached.
O	O	O		Document approved.

QUYNH-DAO T. Ho [signature]

Reviewer (Printed Name and Signature)

6/5/08

Date

*Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

A-6002-359 (02/98)